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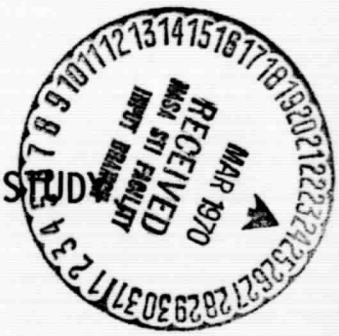
SUMMARY REPORT
INFORMATION TRANSFER SYSTEMS REQUIREMENT STUDY



by W.C. Sedlacek, R.E. Leonard, and J.E. Burtt

Prepared by
LOCKHEED MISSILES & SPACE COMPANY
Sunnyvale, California
for NASA Mission Analysis Division, Office of Advanced Research and Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION •
MOFFET FIELD, CALIFORNIA
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ABSTRACT

INFORMATION TRANSFER SYSTEMS REQUIREMENT STUDY

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Under Contract No. NAS2-5352, awarded to Lockheed Missiles & Space Company in March, 1969, information transfer requirements were investigated and analyzed for the time period 1970 to 1985. Demands for information transfer services were identified and isolated in the order of their apparent relative importance, using the market potential of a particular information need as a major criterion. Relative potential payoff, and functional requirements of the identified demands were also considered. Various conditions were voluntarily accepted in this initial study - such as, (1) maintenance of an objective overview, (2) consideration only of long-haul transfer services, (3) consideration of all potential demands in view of their possible benefits to the United States, and (4) avoidance of detailed analyses of the functions and parameters of advanced information transfer satellites. The principal output of the study was a preliminary cataloging of the most promising information transfer demands, and a categorization of their functional requirements. Over 300 candidate demands were identified and analyzed, of which 31 were selected and are reported upon in some detail.

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SUMMARY AND INTRODUCTION

The transfer of information today is in a self-perpetuating situation in which the demands for service and the development of the capability to satisfy these demands are stimulating each other, generating increasingly higher levels of communication traffic loads, new technology, and operational capabilities. Conventional means for meeting these demands for information transfer services are now being saturated, as evidenced by tieups in our transportation systems - particularly in air traffic control and ground traffic control at major airports - by the recent restricted hours of trading on the New York Stock Exchange, and by the inadequacy of the New York telephone service in the metropolitan area.

The projection of this situation into the next decade, and the availability of new technology advancements that may overcome these saturated communication problems, suggests that studies be made of demands for transfer of information, their requirements, and an overall appraisal of the situation.

In March, 1969, a contract was awarded to Lockheed Missiles & Space Company by the NASA Mission Analysis Division of the Office of Advanced Research and Technology, Moffett Field, California, to study the information transfer requirements for the time period 1970 to 1985. The study objective was broad in concept, because the study was directed toward the market potential for information transfer, but it was not to be considered a "technology assessment" or "benefit analysis." It is a pioneering effort, since it attempts to encompass the entire telecommunications area rather than to deal with specific areas, as has been done in the past, by other organizations. It is to be considered a first iteration of future NASA studies that would become progressively more detailed; thus, it is in no sense a final evaluation or rigid position.

Ths study does provide a look at those demands for information transfer services that are now considered impossible because of the need for technology advancements, such as increasing the broadcast spectrum by using frequencies above 10 GHz. If this kind of capacity can be made available at reasonable rates, it will provide the basis for the all-purpose "home communication center," often mentioned in the popular press. The study also considers the demands for additional services due to inadequacies of conventional services, and it provides NASA with planning data that identify future critical telecommunication areas which might warrant intensified NASA activity.

A study that attempts to provide such an overall perspective of the entire telecommunication field necessarily must operate under certain ground rules which are consistent with the allotted study time and budget considerations. Therefore, it was necessary to limit the study in the following ways:

- Consider only those demands involving long-haul information transfer service. While this restraint reduces the magnitude of the study, it does not

affect results. Short-haul communications service is already receiving a great deal of attention; thus its exclusion does not affect the value of the study results for NASA's purposes.

- Maintain an objective overview and perspective in contrast to a study in depth. Any bias towards any one type of telecommunication or service to satisfy the demand for information transfer would defeat the purpose of the study.

- Consider all information transfer demands that could be found by literature research or by discussion with experts, whether for government (non-defense), business, or private purposes and regardless of geographic location, providing their use benefits the United States.

- Consider only the 1970 and 1985 time periods since these two time periods cover the needs for NASA short and long term planning.

- Consider the change, with time, in the volume of transfer of information to be more important than specific values. This constraint was imposed since exact quantitative data was difficult to determine (particularly for the newer, more rapidly developing information fields) yet contributed very little to the overall study objective of determining trends for information transfer services.

- Consider detailed analysis of functions and parameters of advanced information transfer satellites as outside the scope of this study. This was done to separate the requirements analyses from the design concept phase, the effect being to maintain objectivity in the establishment of requirements.

The term "transfer of information," as used in this study, includes all functions of communications as well as data transfer. "All functions of communications" pertains to electronic communication at a distance. In terms of facilities, it includes telegraph, telephone, radio, television, data transmission, picture transmission - anything in which information is transmitted in the form of an electric signal. It excludes physical distribution of books or face-to-face conversations.

The "demand" for the transfer of information was considered throughout the study as a quantitative measure of the market potential of a particular need. The objective of the study then was to identify these demands, their relative potential payoff and their functional requirements.

With this objective, the following basic issues were confronted by the study:

- What are the magnitudes of the functional requirements for the future information transfer demands?

- Which demands, if satisfied by a service, are most beneficial to the nation?
- Which demands are most amenable to satellite service and government sponsorship?
- Which demands, on the basis of the study, should be further studied by NASA?
- How will the demands for transfer of information change with time?
- What are the commonality factors between demands for transfer of information?

The answers to the preceding questions constitute the principal output of the study; a preliminary cataloging of the most promising information transfer demands and a categorization of their functional requirements are presented in the following sections.

STUDY LOGIC AND APPROACH

The study was a pioneering effort, encompassing the entire telecommunications field, and the accomplishments were broad in scope, with only the necessary minimum detailed analysis being performed. The highlights of the sequential generation and development of the study data, the reiterations, and the results of the five tasks comprising the study are described in the following section.

The study logic recognized the fact that other in-depth studies will be made; consequently, the overall objective was to lay a foundation for these studies. To initiate the study, it was necessary first to generate a list of potential demands for the transfer of information. This list of 134 potential demands (shown below) required a number of interviews and a search of the literature. Futuristic predictions and use of the imagination also played an important part in this process.

LIST OF POTENTIAL DEMANDS

1. Law Enforcement Identification
2. Law Enforcement Records
3. Education, Preschool
4. Education, Grade School
5. Education, High School
6. Education, College
7. Education, Post Graduate
8. Education, Adult Education
9. Education, Developing Nations
10. Education, Criminal Rehabilitation
11. Education, Police Training
12. Education, Ailing at Home
13. Education, Rural Communities
14. Education, Disadvantaged Children

(LIST OF POTENTIAL DEMANDS CONT'D)

15. Education, Welfare Recipients
16. Electronic Mail
17. Blood, Eye, Organ Banks Data
18. Hospital Records Transfer
19. Personal Medical Records
20. Medical Diagnostic Data & Consultation
21. Banking, Checks Transfer
22. Credit Card Records & Identification
23. Banking, Real Time Identification
24. Banking, Service Network
25. Telephone, Voice
26. Videophone
27. News Service
28. Facsimile Publishing Networks
29. Aircraft Communications, Commercial
30. Aircraft Communications, Private
31. Aircraft Passenger Telephone
32. Air Sea Rescue Communications
33. Mobile Ground Communications
34. Library, Public Data Networks
35. Library, Special Data Networks
36. Library, Colleges and Universities Data Networks
37. Library, Public Schools Data
38. Library, Patents Data Remote Access
39. Employment Records and Placement Transfer
40. Social Security Records and Transfer
41. Housing Recording & Information Transfer
42. Land Renewal and Utilization Data
43. Securities Transaction Data
44. Securities Quotation Data
45. Weather Balloon Data
46. Weather, Buoy Data
47. Weather, Satellite Data
48. Weather, Station Data
49. Weather, Ocean Data Ships
50. Weather, Forecast Data
51. Enroute Air Traffic Control, Commercial
52. Enroute Air Traffic Control, Private
53. Aircraft Collision Avoidance
54. Ship Communication, Commercial
55. Ship Communications, Private
56. Ship Communications, Government
57. Ship Position, Commercial
58. Ship Position, Private
59. Ship Position, Government
60. Ship Collision Avoidance
61. Internal Revenue, Personal Data
62. Internal Revenue, Corporation Data
63. Federal Excise Tax Data
64. Customs and Duties Information Transfer
65. State Revenue Data
66. Internal Revenue, Treasury and General Accounting Data
67. Ocean Fishing Data
68. Ship Routing Data
69. Sea State, Ocean Data
70. Ocean Data from Buoys and Ships
71. TV Commercial Broadcast
72. Radio Commercial Broadcast
73. Enroute Aircraft Performance Monitoring
74. Teleconference, United Nations
75. Teleconference, Conventions
76. Teleconference, Business
77. Teleconference, Hot Line
78. Teleconference, Legislative Sessions, Committees
79. Teleconference, Political Conventions
80. Teleconference, Stockholders
81. Teleconference, Union
82. Teleconference, Scientific and Technical Societies
83. Aircraft, Enroute Scheduling and Statusing
84. Ship, Enroute Scheduling and Statusing
85. Train, Enroute Scheduling and Statusing
86. Hotel, Reservation Scheduling and Statusing
87. Bus, Enroute Scheduling and Statusing

(LIST OF POTENTIAL DEMANDS CONT'D)

88. Inventory Control and Monitoring Data
89. Remote Automated Audio or Computer Aided Translation Services
90. Crop Surveillance, Soil Conservation Data, Collection and Dissemination of
91. Geology, Topographic Data, Collection and Dissemination of
92. Precision Surveying Data, Collection and Dissemination of
93. Hydrology, Streams, Data, Collection and Dissemination of
94. Civil Defense, Emergency Warning
95. Civil Defense, Emergency Communications
96. Time Signals Broadcast
97. International Cultural Exchange Program
98. Domestic Cultural Programs, Museums, Galleries, Historical Events
99. Migration Data, Fish
100. Migration Data, Animals
101. Migration Data, Birds
102. Judicial Actions, Proceedings
103. Time Share Computer Services
104. Earth Resources Satellite
105. Manned Orbit Support
106. Astronomy Data
107. Deep Space Data
108. Orbit Computer Facility
109. Satellite Control
110. Assist On-orbit Assembly
111. In-space Performance Testing
112. Ground Traffic Control, City
113. Ground Traffic Control, Highway
114. Tape and Video, Publishing
115. Law Enforcement - Probation Monitoring
116. Law Enforcement - Release on Cognizance
117. Medical, Home Diagnostic and Monitoring
118. Domestic Cultural Programs, Electronic Travel
119. Library, Home Extension
120. Automated Graphic Translation
121. Truck, Scheduling and Statusing
122. Amateur Radio Information
123. Religious Communications
124. Earthquake Monitoring
125. Meeting, Group Therapy
126. TV and Radio Program Distribution
127. Computer Assisted Design, Drafting, etc.
128. Remote Legal Reference Data
129. Time-shared Family Management Assistance
130. Reservations and Schedules
131. Commercial Purchasing Data
132. Home Information Center
133. Home Teletype Mail
134. Time-shared Revenue Assistance Programs

One of the objectives of the study was to predict the most promising of these demands, allowing the subsequent analyses to be concentrated upon them. Therefore, it was necessary to assess the economic growth potential for each demand. Lack of economic data on individual demands made it imperative to relate the demand to an economic grouping (demand indicators) representative of the demand, such as space program expenditures for space program telecommunications; hospital admissions for patient records, etc. From expert predictions of the future, correlation with forcing functions such as the GNP and population, by regression analyses, and by the use of computer prediction techniques, trend curves were generated for these demand indicators. Relating these demand indicator curves to the specific demand permitted the selection of the most promising demands from an economic standpoint.

Due to the magnitude of the list of demands, the constant updating, and the need for cataloging the list in several ways, it was programmed for storage in the computer. As each demand was conceived it was assigned four indices representing the following: numerical, category, group, and user. This allowed the list to be cataloged in four ways. The most useful catalog was by functional categories, which were selected as representing all of the demand titles listed.

INFORMATION TRANSFER DEMAND FUNCTIONAL CATEGORIES

1. Space Programs Data Relay
2. Weather Data Relay
3. Oceanographic Data Relay
4. Earth Sciences Data Relay
5. Aircraft Data Handling
6. Marine Data Handling
7. Rescue Data Handling
8. Ground Traffic Data Handling
9. Statusing of Goods Data
10. Computer Data Handling
11. Point-to-Point Telecommunications
12. Teleconferencing Data
13. News and Broadcast Distribution
14. Electronic Publishing
15. Language Translation
16. Commercial Broadcast
17. Domestic Cultural Programming
18. International Cultural Programming
19. Education Broadcast
20. Library Data Handling
21. Welfare Data Handling
22. Health and Medical Data Transfer
23. Law Enforcement Data Transfer
24. Electronic Mail Transfer
25. Government Auditing Data Transfer
26. Banking and Financial Data Transfer
27. Data Securities Exchange
28. Civil Defense Warning and Communications
29. Amateur Radio Broadcast
30. Religion Exchange
31. Judicial Proceedings Broadcasts
32. Time Signals Broadcasts

To more fully understand each demand functional category, it was necessary to study the category in a general way and document important characteristics by providing a profile on each category. With these profiles and the economic projections of the demand indicators, it was possible to determine the functional requirements on a gross basis. Overall appraisal of the relative importance of the demand was possible at this time and a preliminary selection of demands was initiated. The first selection from a preliminary screened list of demands was based on National Benefits. The overall criterion for this selection was the relative benefit each demand would provide to the United States if a service was implemented to satisfy the demand. The nine judgment factors used were as follows:

- Growth Rate of a service, if provided
- Availability of technology
- Ease of service implementation
- Social acceptability
- Number of users
- Potential beneficiaries
- Social benefits
- Economic benefits
- Scientific benefits

To further screen the demands, and to balance this first evaluation, which emphasized benefits without adequate consideration for service implementation, a second evaluation was made. The objective of this evaluation was to rate each demand in accordance with its amenability to service implementation. The rationale used to determine a demand's amenability to service implementation was based on three general factors. They were:

1. Status of present service - would it encourage the implementation of a new service?

2. Economic considerations - is it unattractive to commercial interests?

3. Service characteristics - would it suggest satellite dominance over a conventional system?

Application of these three general service factors would determine if a demand is amenable to service and would have the unique characteristics of either (1) replacement of a service that is not satisfactory, or (2) of providing a new service; a service that would most likely be government sponsored; and whether it would best be accomplished by a satellite system.

The above service factors were put into the form of questions and were used as criteria to evaluate each demand. A "yes" answer to the following questions indicated the probable amenability of the demand.

- Is service currently unavailable?
- If available, is the current service inadequate?
- If available, is the current service inconvenient?
- Are the operational costs of the current service limiting?
- Are the current development costs excessive?
- Is there a lack of development incentive?
- Are large distances for transmission involved?
- Are large coverage areas involved?
- Are mobile users involved?
- Is flexibility required as to where the service is provided?

Combining these two evaluations for the purpose of obtaining an even more comprehensive selection yielded the final selection of some 31 demands, in 11 different categories, having potential for meeting the established criteria. These demands were categorized into four different types of information transfer networks for implementation. Criteria for these network categories are discussed later. The functional requirements for the 31 demands were refined, analyzed, and cataloged to further define the operating characteristics and capabilities of the services required. A summary of the principal outputs is presented in the text and figures following. Of the original 325 candidate demands for information transfer, the most promising are shown below, very roughly in order of their relative rank.

31 SELECTED REPRESENTATIVE DEMANDS

1. Relay of Medical Diagnostic Data and Consultation Services
2. Relay of Earth Resources Satellite Data
3. Education Programs for Developing Nations
4. Relay of Weather Balloon Data
5. In-Orbit Flight Testing
6. Relay of Weather Buoy Data
7. Relay of Support Data for Man in Orbit
8. Relay of Astronomy Data from Satellite
9. Relay of Satellite Control Data
10. Education Programs for Pre-School Students
11. Aircraft Collision Avoidance Data
12. Education Programs for Grade School Students
13. Education Programs for Adult Students
14. Civil Defense, Emergency Communications
15. United Nations Teleconferencing
16. Centralization and Relaying of Employment Records
17. Relay of Weather Satellite Data
18. Relay of Weather Ships Data
19. Relay Tracking Data for Determining Fish Migration Patterns
20. Relay Tracking Data for Determining Animal Migration Patterns
21. Relay of Deep Space Exploration Data
22. Relay of Orbit Assembly Data
23. Education Programs for Ailing at Home
24. Legislative Teleconferencing
25. Political Teleconferencing
26. Civil Defense, Emergency Warning Data Transmission
27. Education Programs for High School Students
28. Education Programs for Criminal Rehabilitation
29. Education Programs for Rural Communities
30. Enroute Air Traffic Control, Commercial
31. Computational Information Services

Referring the above selected demands to their respective demand categories on Page 6, indicates a good diversification or scatter, and consequently a good representation of all demand categories.

Although categorization of the demands allowed for easier handling of the 134 demands, a further reduction in number of different categories was considered necessary at this point in the study. Reviewing the operational requirements of the selected demands indicated that a commonality characteristics existed that provided categorization on a service network basis. These four networks are described as follows:

I. Information Dissemination and Broadcast Net. This network transfers information from one central terminal to many peripheral terminals. Although there may be some multipoint-to-multipoint information transfer, it is predominantly a one-way transfer of information on a point to multipoint basis, because in some demands, storage and retransmission capability is used to provide service at an appropriate time. Demands partially satisfied by a net of this type include education, commercial broadcasts, newspaper, and electronic publishing.

II. Data Collection and Distribution Net. As the title implies, the data are collected from many sources; then relayed to other terminals. The networks to satisfy this group of demand may store information for short periods and relay after short delays, but chiefly in a real-time mode. Demands typically using this kind of net are: air traffic control, telecommunications of space program data, relay of meteorology data, and the relay of earth resources data.

III. Inquiry and Response Net. Within this network a large number of specialized terminals request information from a central repository which retrieves information requested and responds. Although a large network is entailed, the service specifically is a two-way transfer between two locations, that of inquiry station and that of repository of information. Demands typifying this type of network are relay of libraries data, and storage and retrieval of welfare and medical records.

IV. Computational Net. In this network a computer is time-shared by a group of users. It is closely allied to the inquiry and response net, the difference being that it has the added capability to digest data, make computations, and then respond to instructions. The transmission of data can go either to or from the terminal. Typical demands having these characteristics include scientific telecomputations and home information centers.

Combined, these four types of networks will satisfy any one of the demands that have been studied. Although basically and objectively different, the networks do have overlapping characteristics and, consequently, the identification of one demand with a particular network should not imply that the demand can only be satisfied by the one network. Neither is it intended to imply that only those demands grouped under one network are the only ones to be satisfied by this net.

STUDY RESULTS

The principal outputs of the study were the selection - from a broad spectrum of demands for transfer of information - of those demands which were considered by the study to be most promising, and a set of functional requirements for these selected demands for the 1970, 1975, and 1985 time frames. The definition in contract terms of "most promising" or "high payoff," as established by the study, was those areas which would, first, maintain a relatively high benefit to the U.S. and, second, exhibit characteristics which required advancement beyond the normal projection of conventional terrestrial services.

The selected demands again are shown in the following Table 1, with their functional requirements in summary form for the 1985 time frame. Actually, the functional requirements for the selected demands were completed for the years 1970, 1975, and 1985 and are provided in the Final Report, CR-73421 . Each demand is categorized with a particular network and in order of importance. The

Table 1
SUMMARY OF ITS FUNCTIONAL REQUIREMENTS – 1985

Service and Demand Title (No. of Users, Terminals, Missions)	Types and Quantity of Information				Message Characteristics			
	Voice and Video (Or Voice* Only – Video** Only)			Digital				
	Number of Channels	Channel-Hours Per Year	Time Blocks (1, 2, 3, 4)	Bits Per Year	Quality	Reliability	Privacy	Priority
I. INFORMATION DISSEMINATION AND BROADCAST NETWORK								
Education, Developing Nations (8×10^3 Terminals)	40	160×10^3	2, 3, 4	–	37 DB	Med	Med	Med
Education, Preschool (26×10^6 Users)	1	500	2	–	37 DB	Med	Med	Med
Education, Grade School (30×10^6 Users)	1	365	2	–	37 DB	Med	Med	Med
Education, Adult (157×10^6 Users)	1	363	2	–	37 DB	Med	Med	Med
Civil Defense, Emergency Communications (270×10^6 Users)	–	–	–	163×10^3	10^{-6}	High	Low	Top
Civil Defense, Emergency Communications (270×10^6 Users)	1	24	1, 2, 3, 4	–	37 DB	High	Low	Top
Elec, Meetings, United Nations (174 Members)	36	11×10^5	2, 3	–	37 DB	Med	High	Med
Education, Ailing at Home (30×10^4 Users)	1	2920	2, 3	–	37 DB	Med	Med	Med
Meetings, Legislators (1100 Legislators)	4	88×10^5	2, 3	–	37 DB	Med	High	Med
Meeting, Political (50×10^3 Users)	20	4×10^4	2, 3	–	37 DB	Med	High	Med
Civil Defense, Emergency Warning (270×10^6 Users)	–	–	–	180×10^3	10^{-5}	High	Low	Top
Civil Defense, Emergency Warning (270×10^6 Users)	1	121	1, 2, 3, 4	–	31 DB	High	Low	Top
Education, High School (15×10^6 Users)	1	2000	3	–	37 DB	Med	Med	Med
Education, Criminal Rehab (350×10^3 Users)	1	250	4	–	37 DB	Med	Med	Med
Education, Rural Community (43.5×10^6 Users)	See Education – Criminal Rehabilitation, High School, Adult, and Grade School Demands							
II. DATA COLLECTION AND DISTRIBUTION NETWORK								
Earth Resources Satellite (1 Satellite)	2-4**	24,000	1, 2, 3, 4	–	42 DB	High	High	High
Earth Resources Satellite (1 Satellite)	–	–	–	432×10^9	10^{-6}	High	High	Top
Weather Balloon Data (3500 Balloons)	–	–	–	23×19^{11}	10^{-5}	Med	Low	Med
Orbit-Flight Testing (10 Tests)	–	–	–	262×10^8	10^{-6}	High	High	High
Weather Buoy Data (5000 Buoys)	–	–	–	73×10^{12}	10^{-4}	Med	Low	Med
Manned Orbit Support (10 Missions)	6**	7200	1, 2, 3, 4	–	42 DB	High	High	Top
Manned-Orbit Support (10 Missions)	50*	12×10^3	1, 2, 3, 4	–	45 DB	High	High	Top
Manned-Orbit Support (10 Missions)	–	–	–	43×10^{11}	10^{-6}	Top	High	Top
Astronomy Satellite (1 Satellite)	2-4**	52×10^3	1, 2, 3, 4	–	42 DB	High	Low	High
Astronomy Satellite (1 Satellite)	–	–	–	1280×10^6	10^{-6}	High	Low	High
Satellite Control (5 Terminals)	–	–	–	3150×10^9	10^{-6}	High	High	High
Aircraft Collision Avoidance (12,000 Users)	–	–	–	31.6×10^7	10^{-6}	Top	Low	Top
Weather Satellite (3 Terminals)	5**	44,000	1, 2, 3, 4	–	37 DB	High	Low	High
Weather Satellite (3 Terminals)	–	–	–	700×10^{11}	10^{-6}	High	Low	High
Weather Ocean Data Ships (1000 Ships)	–	–	–	455×10^7	10^{-5}	Med	Low	Low
Migration Data, Fish (1000 Fish)	–	–	–	500×10^4	10^{-5}	Med	Low	Low
Migration Data, Animals (100 Animals)	–	–	–	730×10^3	10^{-5}	Med	Low	Low
Deep Space (5 Probes)	3**	5475	1, 2, 3, 4	–	42 DB	High	Med	High
Deep Space (5 Probes)	–	–	–	6560×10^9	10^{-6}	High	High	Med
On-Orbit Assembly (2 Terminals)	4**	70,000	1, 2, 3, 4	–	42 DB	High	Low	High
On-Orbit Assembly (2 Terminals)	–	–	–	126×10^{10}	10^{-6}	High	High	High
Enroute Air Traffic Control, Commercial (1645 Users Average)	–	–	–	41×10^{10}	10^{-6}	High	Low	High
III. INQUIRY AND RESPONSE NETWORK								
Medical Diagnostic (50 Terminals)	1	34×10^3	2, 3	–	42 DB	High	Med	High
Medical Diagnostic (50 Terminals)	–	–	–	1400×10^3	10^{-6}	High	Med	High
Employment Records (5×10^6 Users)	–	–	–	44×10^7	10^{-5}	High	Med	High
IV. COMPUTER INFORMATION NETWORK								
Computer Time Share Services (1×10^6 Users)	–	–	–	2000×10^{16}	10^{-6}	High	High	High

functional requirements were established to define those characteristics considered to be most significant in regard to further study of a design concept. A brief description of each of the column titles shown in Table 1 is included below to provide a better understanding of the information provided in each column.

Type and Quantity of Information

Throughout the study, the type of information transferred was considered to be either video, voice, or digital. In the time frame of 1970 and 1975, teletype and analog was considered, but within this study they were treated as a form of digital data. In a majority of the demands for information transfer services, voice was required in conjunction with video; consequently, voice was not identified as a separate requirement in these cases. Where voice was used as the only means of information transfer (that is, without video), it was then identified separately (voice*). Conversely, where only video is used, it also is identified separately (video**). All other cases use voice and video. The quantity of information (voice or video) transferred is also provided, with an indication of what time within a 24-hour period the transfer would take place. The first quantization, channel hours per year, is basically an average estimate of the amount of information transferred per year in order to satisfy the demands for 1985. The choice of bits per year as the unit was considered necessary, since some demands had message spacings of weeks or months, making it difficult to use smaller time units of one year. The number of channels required was based on individual demand estimates of message spacing and duration which may be found within the functional requirement matrices included in the working materials for the Final Report. The time period that the transfer of information will likely occur is represented by the following time blocks:

Block	Period of Day
1	0000-0600
2	0600-1200
3	1200-1800
4	1800-2400

The digital information was quantized by using the units "bits per year." These data were derived from the estimates of message spacing and duration provided in the final report, and in working material, copies of which are available.

Message Characteristics

The primary message characteristics were quality, reliability, privacy and priority, described as follows. "Quality of signal" identifies a relatively gross characteristic and its change with time for the particular signal type - voice, video, or digital. The relationship of quality to a quantized figure for voice is based on a signal-to-noise ratio, as follows:

45 db - high quality
30 db - medium quality
20 db - low quality

For the video signal, this relationship was based on a signal-to-noise ratio taken from a report* published by Stanford University in 1967. These values were as follows:

TASO GRADE	RATING	S/N
1	Excellent	42 db
2	Fine	37 db
3	Passible	31 db

The digital signal quality was based on error rates as follows:

Error Rate	Quality
10^{-6}	Excellent
10^{-5}	Fine
10^{-4}	Acceptable

Reliability, privacy, and priority items are described in a qualitative form to provide an indication of those system characteristics the design concept study should strive for. Estimating these characteristics for the various demands made it possible to determine commonalities on a broad base, and also provided an indication of trends with time.

An overall appraisal of the results, that is the functional requirements derived for the selected demands indicated an evolution in usage, a commonality of characteristics and a set of demands that would contribute to the enrichment of the quality of life. It also provided an indication of those demands for services that would predominate in quantity of data to be transferred. Within the video/voice type of information transfer there was one demand for service that, if satisfied, dominated all other selected demands - "teleconferencing of legislators' meetings." In the digital area, the maximum demand for

* "Advanced System for Communications and Education in National Development," Final Report, School of Engineering, Stanford University, 1967.

service was the "computer time share." These two demands overwhelmed their respective categories; therefore, it was necessary to treat them separately in the following analyses of the functional requirements.

Requirements Patterns

Table 1 is a summary of the Information Transfer Functional Requirements for 1985. Similar matrices were provided for 1975 and 1970 in the Final Report, CR-73421 . In the detailed format of Table 1, the data are difficult to appraise. The following figures and tabular material summarize this information so that patterns for the cumulative sample of demands are more apparent. A summary picture showing the number of demands requiring the various information types, is presented in Figure 1.

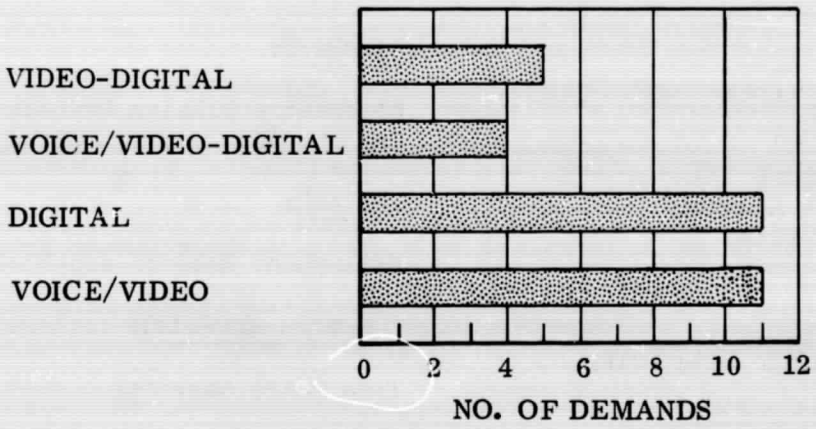


Figure 1 Information Types Vs Number of Demands

From Figure 1 it is seen that a majority of the demands require more than one type of information transfer. The significance of this finding is that a network service to satisfy these demands must be versatile and provide a means for the transfer of all four types of information. In a further analysis of the quantities of information transferred for the 31 selected demands, two categorizations are used; one is the network categorization which is service-oriented and, secondly, a functional categorization. Both have been discussed

previously. The breakdown of the 31 selected demands into their respective functional categories is as follows:

EDUCATION:

Education for Developing Nations
Education for Pre-School
Education for Ailing at Home
Education for High School Student
Education for Criminal Rehabilitation
Education for Rural Schools
Education for Grade School
Education for Adult Education

TELECONFERENCING:

Legislative Meeting or Sessions
Political Presentations and Meetings
U. N. Meetings

SPACE PROGRAMS:

Manned Orbit Support
Astronomy Data
Satellite Control
Deep Space
Assist on Orbit Assembly
Orbit Flight Testing

MEDICAL:

Medical Diagnostic Data Relay

CIVIL DEFENSE:

Emergency Warning
Emergency Communication

EARTH SCIENCES:

Earth Resources
Migration Data Fish
Migration Data Animals

WEATHER DATA:

Weather Balloon Data
Weather Buoy Data
Weather Satellite Data
Weather Ocean Data Ships

AIRCRAFT:

Aircraft Collision Avoidance
Enroute Air Traffic Control, Commercial

WELFARE:

Employment Records and Placement

COMPUTER SERVICES:

Time Share Services

A breakdown of Figure 1 data into these functional categories provides the data for Figure 2, shown on the next page.

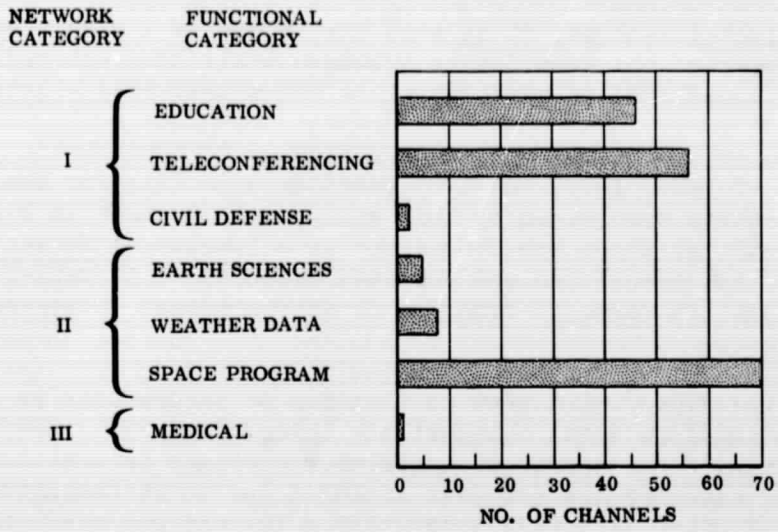


Figure 2 Video/Voice Channels for Selected Demands

From Figure 2, it is seen that the need for video/voice type channels in 1985 is fostered by the demand categories; education, teleconferencing, and space programs.

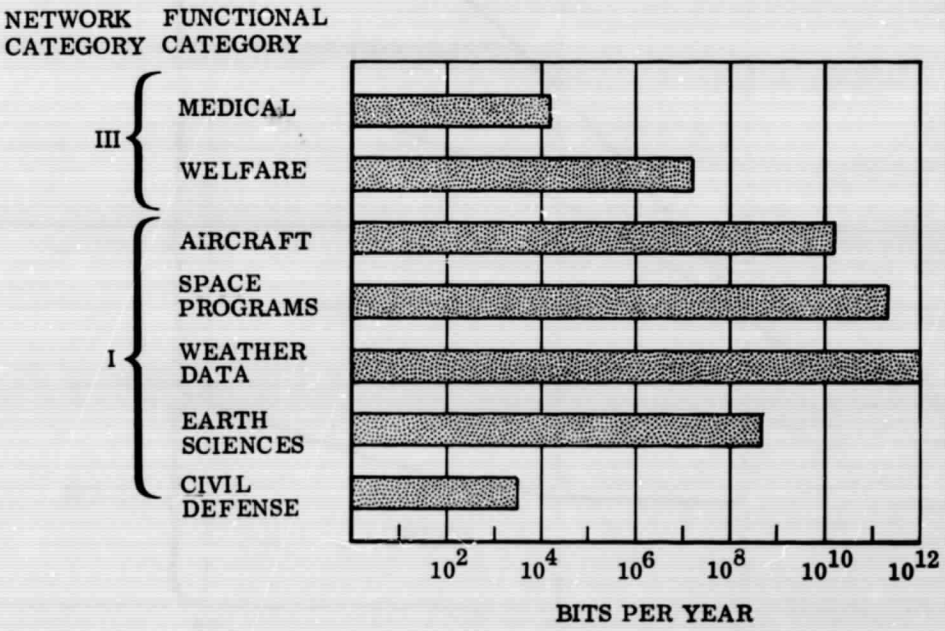


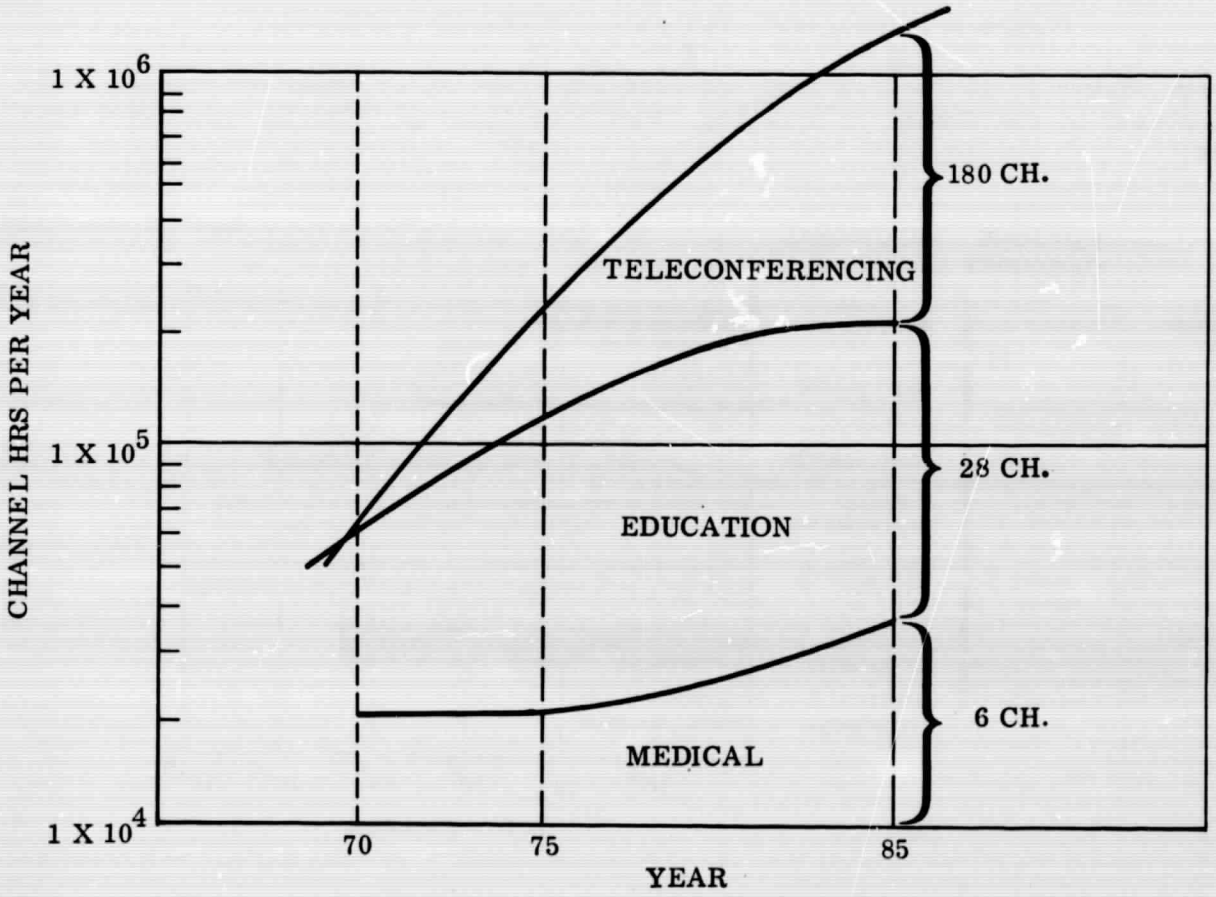
Figure 3 Digital Data Quantities for Selected Demands

Figure 3 shows that the need for digital-type data, although distributed among the demand categories, is predominantly concerned with aircraft, space programs and weather data.

Of the 31 selected demands, it is seen that there is a wide variation in the quality of the message characteristics throughout all four network categories, indicating that excellence of performance is not a universal requirement.

Summarization of the quantity of data estimated to satisfy the 31 demands during the periods of 1970, 1975, and 1985 provides a pattern for the information transfer requirements undertaken by this study, and is shown in Figures 4, 5, 6 and 7. The quantities shown are summarized on a functional category basis for 31 of a total of 134 identified and screened demands. This represents a sample size of 23 percent, in terms of demands, or approximately 30 percent in terms of categories.

In Figure 4 the video/voice type of transfer of information is shown for the three predominating functional categories - teleconferencing, medical, and education. The demand for transfer of Legislator Meetings information under the teleconferencing category has not been included due to its magnitude and swamping effect on all other data (132×10^5, 132×10^5 and 264×10^5 channel hrs/year



NOTE: (1) LEGISLATURE TELECONFERENCING HAS NOT BEEN INCLUDED DUE TO ITS MAGNITUDE

Figure 4 Voice/Video Transfer of Information

for the time periods 1970, 1975 and 1985, respectively). A moderate increase in information transfer is shown during the time period for the three categories. The amount of data represented on a dedicated channel basis for 1985 are 28 channels for education, 6 channels for medical, and 180 channels for teleconferencing. The estimates for number of channels would be modified downward if consideration was given to modulation and radiation techniques. A review of the large number of channels for transfer of teleconferencing data shows that this is due to a wide physical separation of terminals requiring a large number of channels, and continuous use during the working day. Consequently, redundant usage of frequency and narrow antenna bandwidths would be a means of reducing channel requirement. It should also be recognized that this demand is representative of a videophone type service which will take over a great amount of voice-only phone traffic. Consequently, the large quantities of data transferred are understandable. The reader is cautioned that these data are for the selected demands and therefore do not indicate the total traffic load per category.

Figure 5 graphs the data transfer quantities for voice. This figure is based on data transfer requirements that require voice with video as well as the data that are transferred by voice only; consequently, it incorporates Figure 4 data. The significant point to be made is the fact that, although the weather category now makes use of voice, it is anticipated this will be taken over by video as time progresses. Civil defense is in this same period of evaluation whereby, although warnings and communications are to a large extent handled by radio, they eventually will be converted to video as time progresses.

With reference to the message characteristics, it was considered beneficial to determine those characteristics that would be most difficult to achieve on a concept design basis within a network category. These are identified in Table 1 by cross hatching those characteristics by column within a network category. Following is a summary of these data, taken from the table.

NETWORK CATEGORY I

Quality:	Video 37 DB S/N Digital 10^{-5} Error Rate
Reliability:	High
Privacy:	High
Priority:	Top

NETWORK CATEGORY II

Quality:	Video 42 DB S/N Digital 10^{-6} Error Rate
Reliability:	Top
Privacy:	High
Priority:	Top

NETWORK CATEGORY III

Quality:	Video 42 DB S/N Digital 10^{-6} Error Rate
Reliability:	High
Privacy:	Medium
Priority:	High

NETWORK CATEGORY IV

Quality:	Digital 10^{-6} Error Rate
Reliability:	High
Privacy:	High
Priority:	High

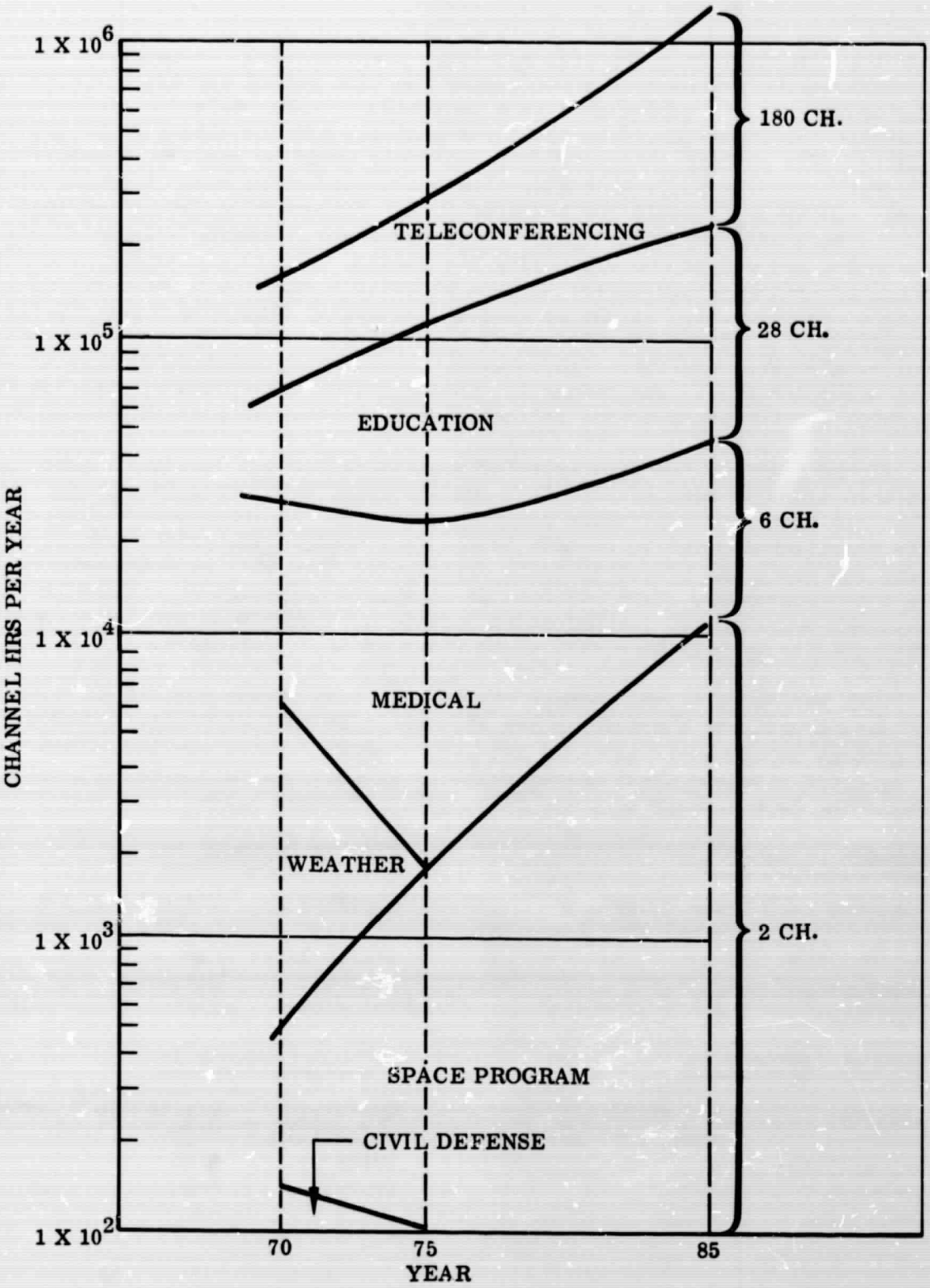


Figure 5 Voice Transfer of Information

Space programs category requirements for voice transfer will increase only due to number of satellites in orbit with no increase in number of channels required. The need for voice transfer in the medical category is expected to increase initially and then decrease as video take over, while education increases in accordance with the demand for video/voice transfer of data.

Teleconferencing will increase throughout the period due to increased usage of video/voice as time progresses. The number of channels required are dedicated channels and therefore indicate a large traffic load; yet this does not represent the total load because this category does not include "legislative teleconferencing". The large traffic load in this category is, of course, because these demands include the transfer of information that is now handled by telephone.

Figure 6 charts the quantity of video information transfer only, for the four categories of Space Programs, Earth Sciences, Weather, and Civil Defense. The increases noted are reasonable; however, the flattening of the curves during the 1975 and 1985 periods is most likely due to the difficulty of forecasting needs in a time period beyond five years.

Figure 7 represents the transfer of digital data for four functional categories - Earth Sciences, Weather, Space Programs, and Aircraft. Three demand categories are not included because of the spread in amounts of data required. The computational category was so large (76×10^{15}, 196×10^{16}, and 2000×10^{16} bits/year for 1970, 1975, and 1985, respectively) that it swamped all other requirements. At the other end of the demand spectrum, Medical (3.5×10^{5}, 3.5×10^{5}, 1.4×10^{6} bits/year for 1970, 1975, and 1985, respectively) was minimal and therefore difficult to plot. Welfare was also minimal (3.2×10^{7}, 3.2×10^{8} and 4.4×10^{8} bits per year for 1970, 1975, 1985). The significance of Figure 7 is the relative growth of the three categories - Weather, Space Programs, and Earth Sciences - during the next five years, as compared with the ensuing ten years from 1975 to 1985. Each one of these categories will most likely be government sponsored. The Aircraft category is considered to be more business-oriented, subject to contingencies based on budget and political considerations, and, consequently, will grow at a more normal rate

CONCLUSIONS

This study was broad and very general in its approach; consequently, the conclusions must be provided in the same vein. Thirty-one most promising demands were selected (see page 8) in accordance with the evaluation parameters established by the study. These demands meet the basic premise of the study - they are beneficial to the nation, they are amenable to a satellite type service, and they are in a category that will be implemented only if they receive government encouragement. However, of the 31 selected demands there were two demands that were considered excellent candidates for the title of "most likely to

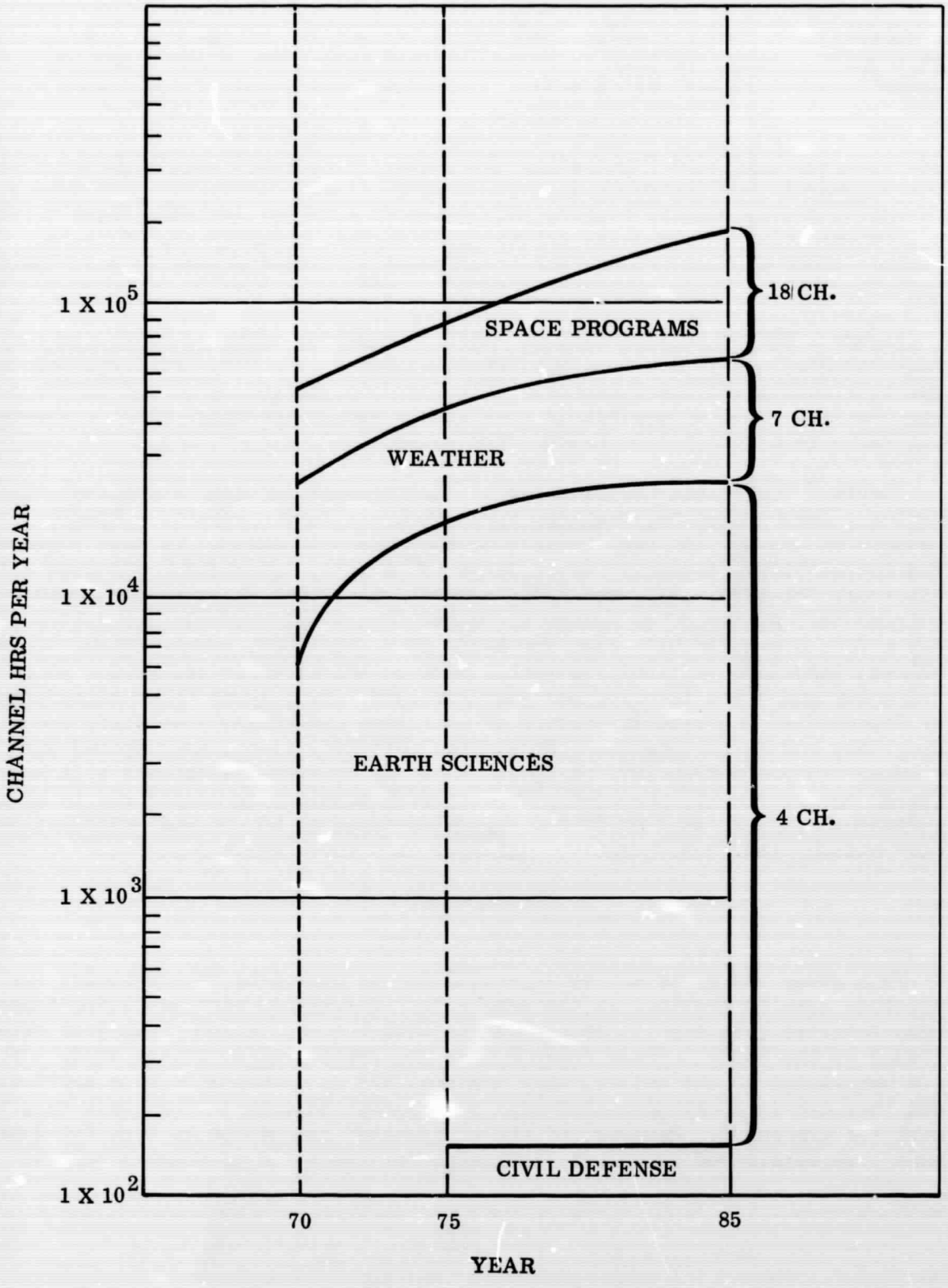


Figure 6 Video Transfer of Information for Selected Demand Categories

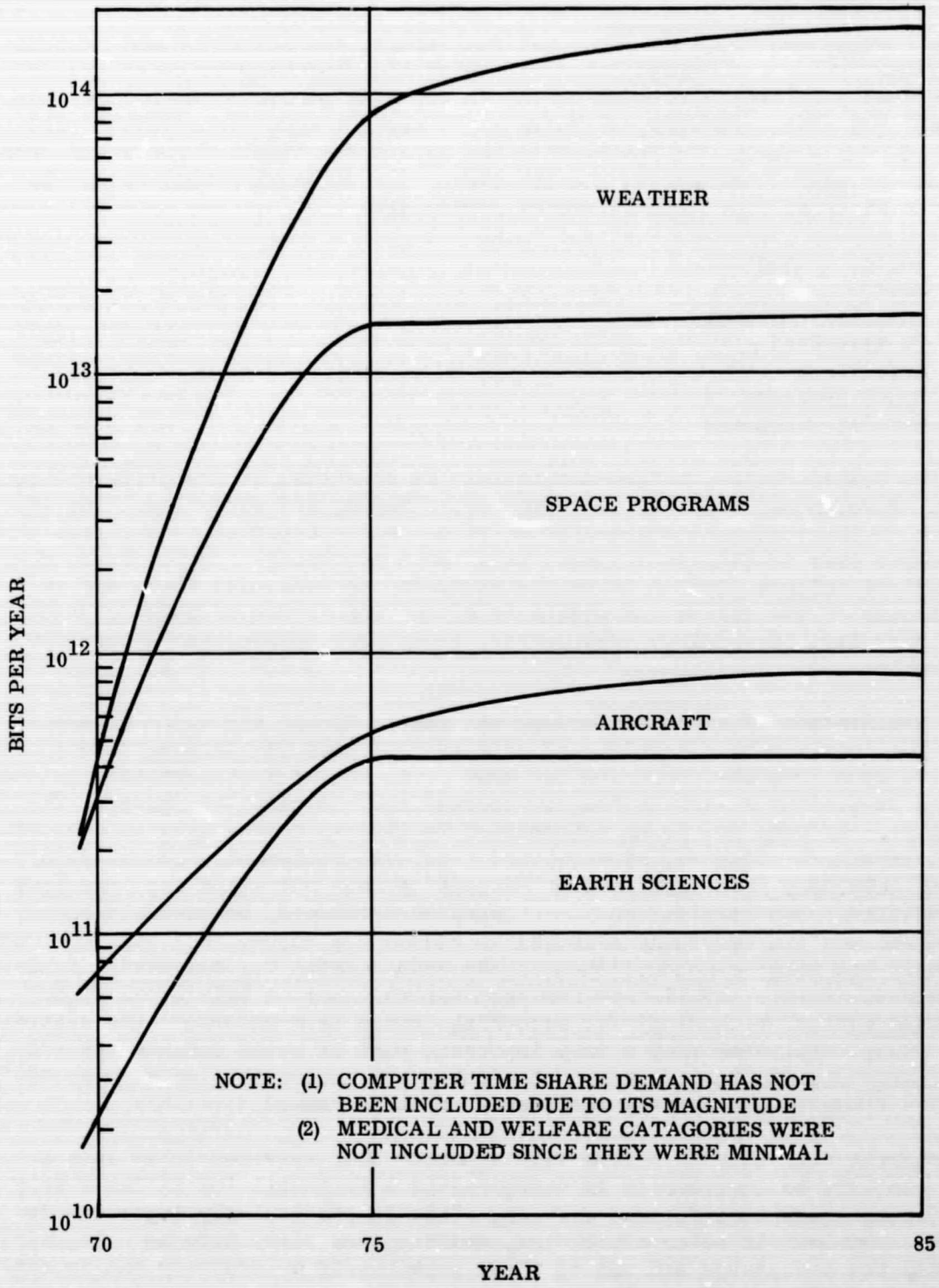


Figure 7 Digital Transfer of Information for Selected Demand Categories

succeed." They are those demands that fall within the Education and Medical categories. These two demand categories have the characteristics of (1) largest projected expenditure of monies in the time period between 1970 and 1990, and (2) egalitarianism, of which there are now many signs which could well lead, for example, to increase in the demand for "public" goods and services such as mass education and health care. The categories that follow the above two categories in expenditure of monies are:

1. Police Protection
2. Welfare
3. Computer Customer
4. TV Advertising
5. Avionics
6. Space Programs
7. Natural Resources

In the United States, telecommunications is essential to the efficient operation of government, industry and commerce, finance, and education. The importance of the information transfer services can be depicted by the fact that it involves over 16 billion dollars, based on a percentage figure of the GNP and constant dollars (1958). From the study it was concluded there are three determinants of the degree and diversity of the future use of telecommunications; they are, technology advancement, social acceptance, and government sponsorship.

The application of a new technology can result in the reduction of costs and in the improvement of quality of conventional communication services; however, its most important contribution must be in the area of terminal equipment. There is at present a lack of "highly specialized" terminal equipment. The assimilation of data now being transmitted is limited by the lack of cost efficient inputting, display, storage, and retrieval equipment. Terminals are becoming saturated with information. Relief of this situation can come from two directions; new terminal equipment must be developed, or the data to be transferred must be carefully selected to reduce the amount to a bare minimum. The latter can only be accomplished if the requirements for selected demands are examined in more detail than has been accomplished in this broad study. The advancement of technology for recording (video tape recorder) and distribution (CATV) will also play a very important part in those demands for education services, due to the fact that editing and redistribution at more appropriate times is a necessary requirement of this demand.

Throughout the study it became very apparent that services to satisfy a demand can only be implemented if there exists a universal (or at least very wide) social acceptance for the service. This is particularly important in the areas involved in teleconferencing, welfare, and civil defense categories. Promoting the acceptance and use of these services is a necessary and important part of implementation. Therefore, the needs for public acceptance should be investigated in depth.

Although one of the parameters used to select the 31 most promising demands was the need for governmental sponsorship, it can be concluded in a general way that government sponsorship must come from one or all of three directions. One is for the government to provide regulatory decisions favoring a more open market in the communication industry. If this comes about, it will help accelerate the rate of introduction of the new, more efficient technologies into the nation's public and private networks. The second is for government to finance many of the demands for service such as earth resources, data relay, and the migration data on fish and animals, since there maybe insufficient profit motivation in those demands that will benefit mankind. Third, a national goal must be established for each of those demands considered to be important to undertake in the next decade. Once this goal is established, the individual design concept problems will be more easily solved, since they will be focussed towards one objective.

The future methods for transferring information, at least for the 31 most promising demands, indicate that the quantity of data transmitted by video data transmission will exceed voice, since the future trend is toward accompanying each voice transmission with a picture, while the reverse is not always true (each video or data transmission does not always need voice). It is also evident from the curves for digital transfer data that this type of information transfer will nearly equal the transfer of video/voice information. On the basis of number of demands for services, the study has indicated generally that the long-haul requirement for transfer of information is approximately 10 percent of the demand for short-haul transfer of information.

A final conclusion drawn from the study experience indicates that the objective of providing functional requirements for the thirty-one selected demands was difficult, since many of the functions were based on assumptions that were subjective and could not be completely documented. These assumptions were critical; for example, in the demand category of teleconferencing, where it was very difficult to determine communication traffic loads - even in the 1970's. It is therefore concluded that the functional requirements should not be accepted as absolute figures but rather as indicators of communication traffic load trends. On this basis, any conclusions drawn from the patterns established by the functional requirements must be tempered by the fact that they were drawn from a general study that indicates a need for a more detailed study of the selected demands.

RECOMMENDATIONS

The conclusions derived from this might suggest advantages of a service dedicated satellite system. Although such an approach is sound, it is time consuming and could be a very expensive program.

Another approach is therefore recommended, one, more within the scope of NASA's objectives, which would prove the practicability of implementing an information transfer service to satisfy selected demands, and would also prove the benefits to be derived, before committing large amounts of money or time. Reference is made to the NASA experimental satellite programs. These programs with launchings from 1972 onwards already incorporate the technology to handle aeronautical communication, educational, and space relay missions which are selected as most promising demands in this study. However, the present approach is basically an experiment to validate technological consideration rather than from a users standpoint. This could be modified by incorporating experiments involving user requirements. An objective to satisfy these requirements would certainly be in consonance with NASA's overall objective of increasing utilization of space capabilities for services to man, through an expanded space applications program.

It therefore is recommended that the following generalized approach be taken to implement a telecommunications experiment on further NASA application satellite systems:

1. Finalize all data provided on the 31 most promising demands, in preparation for reducing the demands to not more than three, by taking the following action:

   a. Detail profiles and researched material compiled on the 31 selected demands.
   b. Firm up functional requirements.
   c. Present the compiled data to the anticipated users (11) in each demand category to obtain either their acceptance or rejection in the form of an expert critique of the material presented.

2. Reduce the 31 demands to not more than three by applying the two techniques already developed; i.e., benefit and amenability to service and by the use of the data provided by Step 1.

3. Relate the newly selected demands to the experimental satellite concepts:

   a. Investigate and provide ground system requirements.
   b. Investigate and provide satellite system requirements.

4. Document the requirements for presentation to the cognizant NASA satellite experiment offices.

5. Formulate an "Information Transfer Experiment" objective and test plan.